

- 1 1. A method for balancing a loading of a storage device attached to multiple
2 computing systems during transfer of a requested data object to or from said data
3 storage device, comprising the steps of:

4 acquiring a listing of locations of all segments of the requested data object
5 including all copies of said segments of the requested data object;

6 evaluating the loading of the storage devices attached to the multiple computing
7 systems containing all copies of all segments of a requested data object;

8 selecting storage devices containing copies of each segment of the data object
9 having a least loading and is less than a maximum loading for said storage
10 devices;

11 if the loading of the storage devices is greater than the maximum loading for
12 said storage devices, generating a sub-segment list for any segment of the
13 requested data object residing on said storage device would have a loading
14 greater than the maximum loading if said segment of the requested data
15 object were transferred, determining a load margin for all available storage
16 devices, assigning locations for each sub-segment on each available
17 storage device having the least loading, and assigning file names to each
18 sub-segment;

19 selecting said each available storage device containing each segment and sub-
20 segment; and

transferring those segments of said requested data object to a requesting
computer system.

2. The method of claim 1 wherein calculating the new sub-segment size list comprises
the steps of:

determining a number of all available storage devices that may retain a plurality
of sub-segments of said sub-segment of the requested data object;

determining a maximum data object transfer load for the available storage
devices;

assigning a minimum sub-segment size which is the smallest amount of data to
be contained within one sub-segment of the segment;

calculating a first sub-segment size as a first function of a number of the storage
devices, the current digital data transfer load, the maximum digital data
transfer load, and the minimum sub-segment size;

assigning a last sub-segment size as the minimum sub-segment size;

calculating all remaining sub-segment sizes as a second function of the number
of the storage devices, the current digital data transfer load, the maximum
data object transfer load, and the minimum sub-segment size; and

partitioning said segment into sub-segments whereby the first sub-segment of
the segment is of the first sub-segment size, the last sub-segment of the

segment is of the last sub-segment size, and all the remaining sub-segments of the segment is of the remaining sub-segment sized.

3. The method of claim 2 wherein the first function to determine the first sub-segment size is:

$$\text{SubSeg1} = \min(\text{SubSegSize}_{\min}, V/f)$$

where

SubSeg1 is the first sub-segment size,

min is the minimum function of two variables,

V is a total size of a segment of the data object, and

f is determined by the formula:

$$f = N_d + \left(\frac{M_i}{M_i - C_i} \right)$$

where

N_d is the number of storage devices available to retain the sub-segments of the segments of the data object,

M_i is the maximum data object transfer load, and

C_i is the current data object transfer load.

4. The method of claim 2 wherein the second function to determine the remaining sub-segment sizes is:

$$\text{SubSegn} = \max(\text{SubSegSize}_{\min}, V/f)$$

where

SubSegn is the a sub-segment size for one sub-segment of the remaining sub-segments,

max is the maximum function of two variables,

V is a total size of a segment of the data object, and

f is determined by the formula:

$$f = N_d + \left(\frac{M_i}{M_i - C_i} \right)$$

where

N_d is the number of storage devices available to retain the sub-segments of the segments of the data object,

M_i is the maximum data object transfer load, and

C_i is the current data object transfer load.

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1 5. The method of claim 2 wherein calculating the new sub-segment size list further
2 comprises the step of:

3 determining a file interactivity factor describing a number of jumps by the
4 second computing system within the data object.

1 6. The method of claim 5 wherein the first function is further dependent upon the file
2 interactivity factor.

3 7. The method of claim 6 wherein the first function to determine the first sub-segment
4 size is:

$$\text{SubSeg1} = \min(\text{SubSegSize}_{\min}, V/f)$$

where

SubSeg1 is the first sub-segment size,

min is the minimum function of two variables,

V is a total size of a segment of the data object, and

f is determined by the formula:

$$f = N_d + \left(\frac{M_i}{M_i - C_i} \right) + 1$$

where

N_d is the number of storage devices available to
retain the sub-segments of the segments
of the data object,

M_l is the maximum data object transfer load,

C_l is the current data object transfer load, and

I is the file interactivity factor.

8. The method of claim 5 wherein the second function is further dependent upon the
file interactivity factor.

9. The method of claim 8 wherein the second function to determine the remaining
sub-segment sizes is:

$$\text{SubSegn} = \max(\text{SubSegSize}_{\min}, V/f)$$

where

SubSegn is the a sub-segment size for one sub-segment of
the remaining sub-segments,

max is the maximum function of two variables,

V is a total size of a segment of the data object, and

f is determined by the formula:

$$f = N_d + \left(\frac{M_i}{M_i - C_i} \right) + I$$

where

N_d is the number of storage devices available to retain the sub-segments of the segments of the data object,

M_i is the maximum data object transfer load,

C_i is the current data object transfer load, and

I is the file Inter activity factor.

10. The method of claim 2 wherein calculating the new sub-segment size list further comprises the step of:

determining a file usage factor describing a number of requests for said data object for a period of time.

11. The method of claim 10 wherein the first function is further dependent upon the file usage factor.

12. The method of claim 11 wherein the first function to determine the first sub-segment size is:

$$\text{SubSeg1} = \min(\text{SubSegSize}_{\min}, V/f)$$

where

SubSeg1 is the first sub-segment size,

min is the minimum function of two variables,

V is a total size of a segment of the data object, and

f is determined by the formula:

$$f = N_d + \left(\frac{M_i}{M_i - C_i} \right) + H$$

where

N_d is the number of storage devices available to retain the sub-segments of the segments of the data object,

M_i is the maximum data object transfer load,

C_i is the current data object transfer load, and

H is the file usage factor.

13. The method of claim 9 wherein the second function is further dependent upon the file usage factor.

14. The method of claim 13 wherein the second function to determine the remaining sub-segment sizes is:

$$\text{SubSegn} = \max(\text{SubSegSize}_{\min}, V/f)$$

where

SubSegn is the a sub-segment size for one sub-segment of the remaining sub-segments,

max is the maximum function of two variables,

V is a total size of a segment of the data object, and

f is determined by the formula:

$$f = N_d + \left(\frac{M_i}{M_i - C_i} \right) + H$$

where

N_d is the number of storage devices available to retain the sub-segments of the segments of the data object,

M_i is the maximum data object transfer load,

C_i is the current data object transfer load, and

H is the file usage factor.

15. The method of claim 2 wherein calculating the new sub-segment size list further comprises the steps of:

determining a file usage factor describing a number of requests for said data object for a period of time; and

determining a file interactivity factor describing a number of jumps by the second computing system within the data object.

16. The method of claim 15 wherein the first function is further dependent upon the file usage factor and the file interactivity factor.

17. The method of claim 16 wherein the first function to determine the first sub-segment size is:

$$\text{SubSeg1} = \min(\text{SubSegSize}_{\min}, V/f)$$

where

SubSeg1 is the first sub-segment size,

min is the minimum function of two variables,

V is a total size of a segment of the data object, and

f is determined by the formula:

$$f = N_d + \left(\frac{M_i}{M_i} - C_i \right) + H + I$$

where

N_d is the number of storage devices available to retain the sub-segments of the segments of the data object,

M_i is the maximum data object transfer load,

C_i is the current data object transfer load,

H is the file usage factor, and

I is the file Inter activity factor.

18. The method of claim 15 wherein the second function is further dependent upon the file usage factor and the file interactivity factor.

19. The method of claim 18 wherein the second function to determine the remaining sub-segment sizes is:

$$\text{SubSegn} = \max(\text{SubSegSize}_{\min}, V/f)$$

where

SubSegn is the a sub-segment size for one sub-segment of the remaining sub-segments,

max is the maximum function of two variables,

V is a total size of a segment of the data object, and

f is determined by the formula:

$$f = N_d + \left(\frac{M_i}{M_i - C_i} \right) + H$$

where

N_d is the number of storage devices available to
retain the sub-segments of the segments
of the data object,

M_i is the maximum data object transfer load,

C_i is the current data object transfer load, and

H is the file usage factor.

20. The method of claim 1 further comprising the steps of:

determining the presence of all segments and sub-segments of the requested
data object;

if there are missing segments and sub-segments of the requested data object,
assigning each of those missing segments and sub-segments a file
identification and file location, such that those missing segments and sub-

segments are assigned to data storage devices having the least loading;
and

retrieving those missing segments and sub-segments from a back-up storage
device.

21. The method of claim 1 wherein selecting the storage devices containing copies of
the segments of the requested data object and having the least loading comprises
the steps of:

setting a current segment indicator to indicate which of the segments of the data
object is to be transferred next;

setting a current storage device indicator to specify a primary location of the
segment to be transferred next;

if the transfer of said segment causes the loading of the storage device
containing said segment to be exceeded, incrementing the current storage
device indicator to a next location of the segment to be transferred; and

repeated executing step c) until said loading is not exceeded.

22. The method of claim 1 wherein transferring of the segments of the data object
comprises the actions of reading said segments from the data storage device,
writing said segments to the data storage device, and copying said segments from
a said data storage device to an alternate data storage device, whereby said

loading of the data storage device is allocated between the reading, writing, and copying of the segments to prevent interference with said reading of the segments.

23. The method of claim 1 wherein the requested data object is a video data file to be streamed isochronously to the requesting computer system.

24. A data object service system in communication with a plurality of computing systems to provide at least one data object of plurality of data object to at least one of the plurality of computing system, comprising:

a plurality of data object storage devices in communication with each other and with any of the plurality of computing systems; and

a load balancing apparatus in communication with the plurality of data object storage devices to balance a loading of said data object storage devices during transfer of said data objects,

whereby said load balancing apparatus comprises:

a load evaluator to assess the loading of the data object storage devices containing segments of said data objects,

a storage device selector to create a selection list to indicate selection of those data object storage devices containing copies of each segment of the requested data object having the least loading, and

15 a coping initiator to initiate a copying and further segmenting of a
16 segment of the data object to an alternate storage devices having low
17 loading if all storage devices containing said segment have a loading
18 greater than a maximum loading, whereby said copying initiator
19 generates a sub-segment list for any segment of the requested data
20 object residing on said storage device that would have a loading
21 greater than the maximum loading if said segment of the requested
22 data object were transferred, determines a load margin for all
23 available storage devices, assigns locations for each sub-segment on
24 each available storage device having the least loading, and assigns
25 file names to each sub-segment;

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calculating a first sub-segment size as a first function of a number of the storage devices, the current digital data transfer load, the maximum digital data transfer load, and the minimum sub-segment size;

assigning a last sub-segment size as the minimum sub-segment size;

calculating all remaining sub-segment sizes as a second function of the number of the storage devices, the current digital data transfer load, the maximum data object transfer load, and the minimum sub-segment size; and

partitioning said segment into sub-segments whereby the first sub-segment of the segment is of the first sub-segment size, the last sub-segment of the segment is of the last sub-segment size, and all the remaining sub-segments of the segment is of the remaining sub-segment sized.

26. The system of claim 25 wherein the first function to determine the first sub-segment size is:

$$\text{SubSeg1} = \min(\text{SubSegSize}_{\min}, V/f)$$

where

SubSeg1 is the first sub-segment size,

min is the minimum function of two variables,

V is a total size of a segment of the data object, and

f is determined by the formula:

$$f = N_d + \left(\frac{M_i}{M_i - C_i} \right)$$

where

N_d is the number of storage devices available to retain the sub-segments of the segments of the data object,

M_i is the maximum data object transfer load, and

C_i is the current data object transfer load.

27. The system of claim 25 wherein the second function to determine the remaining sub-segment sizes is:

$$\text{SubSegn} = \max(\text{SubSegSize}_{\min}, V/f)$$

where

SubSegn is the a sub-segment size for one sub-segment of the remaining sub-segments,

max is the maximum function of two variables,

V is a total size of a segment of the data object, and

9 **f** is determined by the formula:

10
$$\mathbf{f} = \mathbf{N}_d + \left(\frac{\mathbf{M}_l}{\mathbf{M}_l - \mathbf{C}_l} \right)$$

11 where

- 12 (a) **N_d** is the number of storage devices
13 available to retain the sub-
14 segments of the segments of the
15 data object,
16 (b) **M_l** is the maximum data object
17 transfer load, and
18 (c) **C_l** is the current data object transfer
19 load.

18 28. The system of claim 25 wherein calculating the new sub-segment size list further
2 comprises the step of:

3 determining a file interactivity factor describing a number of jumps by the
4 second computing system within the data object.

1 29. The system of claim 28 wherein the first function is further dependent upon the file
2 interactivity factor.

30. The system of claim 29 wherein the first function to determine the first sub-segment size is:

$$\text{SubSeg1} = \min(\text{SubSegSize}_{\min}, V/f)$$

where

SubSeg1 is the first sub-segment size,

min is the minimum function of two variables,

V is a total size of a segment of the data object, and

f is determined by the formula:

$$f = N_d + \left(\frac{M_l}{M_l - C_l} \right) + 1$$

where

(a) **N_d** is the number of storage devices available to retain the sub-segments of the segments of the data object,

(b) **M_l** is the maximum data object transfer load,

(c) C_i is the current data object transfer load, and

(d) I is the file interactivity factor.

31. The system of claim 28 wherein the second function is further dependent upon the file interactivity factor.

32. The system of claim 31 wherein the second function to determine the remaining sub-segment sizes is:

$$\text{SubSegn} = \max(\text{SubSegSize}_{\min}, V/f)$$

where

SubSegn is the a sub-segment size for one sub-segment of the remaining sub-segments,

max is the maximum function of two variables,

V is a total size of a segment of the data object, and

f is determined by the formula:

$$f = N_d + \left(\frac{M_i}{M_i - C_i} \right) + I$$

where

(a) N_d is the number of storage devices available to retain the sub-segments of the segments of the data object,

(b) M_l is the maximum data object transfer load,

(c) C_l is the current data object transfer load, and

(d) I is the file Inter activity factor.

33. The system of claim 25 wherein calculating the new sub-segment size list further comprises the step of:

determining a file usage factor describing a number of requests for said data object for a period of time.

34. The system of claim 33 wherein the first function is further dependent upon the file usage factor.

35. The system of claim 34 wherein the first function to determine the first sub-segment size is:

$$\text{SubSegl} = \min(\text{SubSegSize}_{\min}, V/f)$$

where

SubSeg1 is the first sub-segment size,

min is the minimum function of two variables,

V is a total size of a segment of the data object, and

f is determined by the formula:

$$f = N_d + \left(\frac{M_l}{M_l - C_l} \right) + H$$

where

- (a) **N_d** is the number of storage devices available to retain the sub-segments of the segments of the data object,
- (b) **M_l** is the maximum data object transfer load,
- (c) **C_l** is the current data object transfer load, and
- (d) **H** is the file usage factor.

36. The system of claim 33 wherein the second function is further dependent upon the file usage factor.

37. The system of claim 36 wherein the second function to determine the remaining sub-segment sizes is:

$$\text{SubSegn} = \max(\text{SubSegSize}_{\min}, V/f)$$

where

SubSegn is the a sub-segment size for one sub-segment of the remaining sub-segments,

max is the maximum function of two variables,

V is a total size of a segment of the data object, and

f is determined by the formula:

$$f = N_d + \left(\frac{M_i}{M_i - C_i} \right) + H$$

where

(a) **N_d** is the number of storage devices available to retain the sub-segments of the segments of the data object,

(b) M_i is the maximum data object transfer load,

(c) C_i is the current data object transfer load, and

(d) H is the file usage factor.

38. The system of claim 25 wherein calculating the new sub-segment size list further comprises the steps of:

determining a file usage factor describing a number of requests for said data object for a period of time; and

determining a file interactivity factor describing a number of jumps by the second computing system within the data object.

39. The system of claim 38 wherein the first function is further dependent upon the file usage factor and the file interactivity factor.

40. The system of claim 39 wherein the first function to determine the first sub-segment size is:

$$\text{SubSeg1} = \min(\text{SubSegSize}_{\min}, V/f)$$

where

SubSeg1 is the first sub-segment size,

6

min is the minimum function of two variables,

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V is a total size of a segment of the data object, and

8

f is determined by the formula:

9

$$f = N_d + \left(\frac{M_i}{M_i - C_i} \right) + H + I$$

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where

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(a) **N_d** is the number of storage devices
available to retain the sub-
segments of the segments of the
data object,

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(b) **M_i** is the maximum data object
transfer load,

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(c) **C_i** is the current data object transfer
load,

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(d) **H** is the file usage factor, and

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(e) **I** is the file Inter activity factor.

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41. The system of claim 38 wherein the second function is further dependent upon the

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file usage factor and the file interactivity factor.

42. The system of claim 41 wherein the second function to determine the remaining sub-segment sizes is:

$$\text{SubSegn} = \max(\text{SubSegSize}_{\min}, V/f)$$

where

(a) **SubSegn** is the a sub-segment size for one sub-segment of the remaining sub-segments,

(b) **max** is the maximum function of two variables,

(c) **V** is a total size of a segment of the data object, and

(d) **f** is determined by the formula:

$$(i) \quad f = N_d + \left(\frac{M_i}{M_i - C_i} \right) + H$$

(ii) where

(iii) **N_d** is the number of storage devices available to retain the sub-segments of the segments of the data object,

(iv) M_i is the maximum data
object transfer load,

(v) C_i is the current data object
transfer load, and

(vi) H is the file usage factor.

43. The system of claim 24 wherein the load balancing apparatus generates a listing of
all copies of all segments of the requested data objects.

44. The system of claim 24 wherein a data storage device having a copied segment of
the requested data object is selected to transfer said data object to a requesting
computing system.

45. The system of claim 24 wherein the load balancing apparatus comprises:

a presence determining device to determine the presence of all segments and
sub-segments of the requested data object; and

a segment retrieving device which, if there are missing segments and sub-
segments and sub-segments of the requested data object, said segment
retrieving device assigns each of those missing segments and sub
segments a file identification and file location, such that those missing
segments are assigned to data storage devices having the least loading,
and then said segment retrieving device retrieves those missing segments
from a back-up storage device.

1 46. The system of claim 24 wherein the load balancing apparatus further comprises:

2 a segment indicator that is set to indicate which of the segments of the data
3 object to be transferred next; and

4 a current storage device indicator to specify initially a primary location of the
5 segment identified by the segment indicator;

6 whereby the load balancing apparatus

7 determines if the loading of the data storage device indicated by the
8 current storage device indicator exceeds the maximum loading with
9 transfer of the segment indicated by the segment indicator,

10 if said loading exceeds the maximum loading, the current storage device
11 indicator is set to a next location of the segment indicated by the
12 segment indicator, and

13 repeated executes steps a) and b) until said loading is not exceeded.

1 47. The system of claim 24 wherein transferring of the segments of the data object

2 comprises the actions of reading said segments from the data storage device,

3 writing said segments to the data storage device, and copying said segments from

4 a said data storage device to an alternate data storage device, whereby said

5 loading of the data storage device is allocated between the reading, writing, and

6 copying of the segments to prevent interference with said reading of the segments.

1 48. The system of claim 24 wherein the requested data object is a video data file to be
2 streamed isochronously to the requesting computer system.

1 49. An apparatus for balancing a loading of a storage device attached to multiple
2 computing systems comprising:

3 means for acquiring a listing of locations of all segments of a requested data
4 object including all copies of said segments and sub-segments of the
5 requested data object;

6 means for evaluating the loading of the storage devices attached to the multiple
7 computing systems containing all copies of all segments of a requested data
8 object;

9 means for selecting storage devices containing copies of each segment of the
10 data object having a least loading, which is less than a maximum loading for
11 said storage devices;

12 means for generating a sub-segment list for any segment of the requested data
13 object residing on said storage device would have a loading greater than the
14 maximum loading if said segment of the requested data object were
15 transferred,

16 means for determining a load margin for all available storage devices;

17 means for assigning locations for each sub-segment on each available storage
18 device having the least loading;

means for assigning file names to each sub-segment,

whereby said means for generating a sub-segment list, said means for

determining a load margin, said means for assigning locations for each sub-

segment, and said means for assigning file names function if the loading of

the storage devices is greater than the maximum loading for said storage

devices;

means for selecting said each available storage device containing each sub-

segment; and

means for transferring those segments of said requested data object to a

requesting computer system.

50. The apparatus of claim 49 wherein calculating the new sub-segment size list comprises the steps of:

determining a number of all available storage devices that may retain a plurality of sub-segments of said sub-segment of the requested data object;

determining a maximum data object transfer load for the available storage devices;

assigning a minimum sub-segment size which is the smallest amount of data to be contained within one sub-segment of the segment;

calculating a first sub-segment size as a first function of a number of the storage devices, the current digital data transfer load, the maximum digital data transfer load, and the minimum sub-segment size;

assigning a last sub-segment size as the minimum sub-segment size;

calculating all remaining sub-segment sizes as a second function of the number of the storage devices, the current digital data transfer load, the maximum data object transfer load, and the minimum sub-segment size; and

partitioning said segment into sub-segments whereby the first sub-segment of the segment is of the first sub-segment size, the last sub-segment of the segment is of the last sub-segment size, and all the remaining sub-segments of the segment is of the remaining sub-segment sized.

51. The apparatus of claim 50 wherein the first function to determine the first sub-segment size is:

$$\text{SubSeg1} = \min(\text{SubSegSize}_{\min}, V/f)$$

where

SubSeg1 is the first sub-segment size,

min is the minimum function of two variables,

V is a total size of a segment of the data object, and

f is determined by the formula:

$$f = N_d + \left(\frac{M_i}{M_i - C_i} \right)$$

where

N_d is the number of storage devices available to
retain the sub-segments of the segments
of the data object,

M_i is the maximum data object transfer load, and

C_i is the current data object transfer load.

52. The apparatus of claim 51 wherein the second function to determine the remaining sub-segment sizes is:

$$\text{SubSegn} = \max(\text{SubSegSize}_{\min}, V/f)$$

where

SubSegn is the a sub-segment size for one sub-segment of
the remaining sub-segments,

max is the maximum function of two variables,

V is a total size of a segment of the data object, and

f is determined by the formula:

$$f = N_d + \left(\frac{M_i}{M_i - C_i} \right)$$

where

N_d is the number of storage devices available to retain the sub-segments of the segments of the data object,

M_i is the maximum data object transfer load, and

C_i is the current data object transfer load.

53. The apparatus of claim 50 wherein calculating the new sub-segment size list further comprises the step of:

determining a file interactivity factor describing a number of jumps by the second computing system within the data object.

54. The apparatus of claim 53 wherein the first function is further dependent upon the file interactivity factor.

55. The apparatus of claim 54 wherein the first function to determine the first sub-segment size is:

$$\text{SubSeg1} = \min(\text{SubSegSize}_{\min}, V/f)$$

where

SubSeg1 is the first sub-segment size,

min is the minimum function of two variables,

V is a total size of a segment of the data object, and

f is determined by the formula:

$$f = N_d + \left(\frac{M_l}{M_l - C_l} \right) + I$$

where

N_d is the number of storage devices available to
retain the sub-segments of the segments
of the data object,

M_l is the maximum data object transfer load,

C_l is the current data object transfer load, and

I is the file interactivity factor.

56. The apparatus of claim 53 wherein the second function is further dependent upon
the file interactivity factor.

57. The apparatus of claim 56 wherein the second function to determine the remaining
sub-segment sizes is:

$$\text{SubSegn} = \max(\text{SubSegSize}_{\min}, V/f)$$

where

SubSegn is the a sub-segment size for one sub-segment of the remaining sub-segments,

max is the maximum function of two variables,

V is a total size of a segment of the data object, and

f is determined by the formula:

$$f = N_d + \left(\frac{M_i}{M_i - C_i} \right) + I$$

where

N_d is the number of storage devices available to retain the sub-segments of the segments of the data object,

M_i is the maximum data object transfer load,

C_i is the current data object transfer load, and

I is the file Inter activity factor.

58. The apparatus of claim 50 wherein calculating the new sub-segment size list further comprises the step of:

determining a file usage factor describing a number of requests for said data object for a period of time.

59. The apparatus of claim 58 wherein the first function is further dependent upon the file usage factor.

60. The apparatus of claim 59 wherein the first function to determine the first sub-segment size is:

$$\text{SubSeg1} = \min(\text{SubSegSize}_{\min}, V/f)$$

where

SubSeg1 is the first sub-segment size,

min is the minimum function of two variables,

V is a total size of a segment of the data object, and

f is determined by the formula:

$$f = N_d + \left(\frac{M_i}{M_i - C_i} \right) + H$$

where

N_d is the number of storage devices available to
retain the sub-segments of the segments
of the data object,

M_l is the maximum data object transfer load,

C_l is the current data object transfer load, and

H is the file usage factor.

61. The apparatus of claim 58 wherein the second function is further dependent upon
the file usage factor.

62. The apparatus of claim 61 wherein the second function to determine the remaining
sub-segment sizes is:

$$\text{SubSegn} = \max(\text{SubSegSize}_{\min}, V/f)$$

where

SubSegn is the a sub-segment size for one sub-segment of
the remaining sub-segments,

max is the maximum function of two variables,

V is a total size of a segment of the data object, and

f is determined by the formula:

$$f = N_d + \left(\frac{M_i}{M_i - C_i} \right) + H$$

where

N_d is the number of storage devices available to retain the sub-segments of the segments of the data object,

M_i is the maximum data object transfer load,

C_i is the current data object transfer load, and

H is the file usage factor.

63. The apparatus of claim 50 wherein calculating the new sub-segment size list further comprises the steps of:

determining a file usage factor describing a number of requests for said data object for a period of time; and

determining a file interactivity factor describing a number of jumps by the second computing system within the data object.

64. The apparatus of claim 63 wherein the first function is further dependent upon the file usage factor and the file interactivity factor.

65. The apparatus of claim 64 wherein the first function to determine the first sub-segment size is:

$$\text{SubSeg1} = \min(\text{SubSegSize}_{\min}, V/f)$$

where

SubSeg1 is the first sub-segment size,

min is the minimum function of two variables,

V is a total size of a segment of the data object, and

f is determined by the formula:

$$f = N_d + \left(\frac{M_i}{M_i - C_i} \right) + H + I$$

where

N_d is the number of storage devices available to
retain the sub-segments of the segments
of the data object,

M_i is the maximum data object transfer load,

C_i is the current data object transfer load,

H is the file usage factor, and

I is the file Inter activity factor.

66. The apparatus of claim 63 wherein the second function is further dependent upon the file usage factor and the file interactivity factor.

67. The apparatus of claim 66 wherein the second function to determine the remaining sub-segment sizes is:

$$\text{SubSegn} = \max(\text{SubSegSize}_{\min}, V/f)$$

where

SubSegn is the a sub-segment size for one sub-segment of the remaining sub-segments,

max is the maximum function of two variables,

V is a total size of a segment of the data object, and

f is determined by the formula:

$$f = N_d + \left(\frac{M_i}{M_i - C_i} \right) + H$$

where

N_d is the number of storage devices available to retain the sub-segments of the segments of the data object,

M_i is the maximum data object transfer load,

16 C_i is the current data object transfer load, and

17 H is the file usage factor.

1 68. The apparatus of claim 49 further comprising:

2 means for determining the presence of all segments and sub-segments of the
3 requested data object;

4 means for assigning each of those missing segments a file identification and file
5 location, such that those missing segments are assigned to data storage
6 devices having the least loading, if there are missing segments and sub-
7 segments of the requested data object; and

8 means for retrieving those missing segments from a back-up storage device.

9 69. The apparatus of claim 68 wherein the means for selecting the storage devices
10 containing copies of the segments and sub-segments of the requested data object
11 and having the least loading comprises:

4 means for setting a current segment indicator to indicate which of the segments
5 of the data object is to be transferred next;

6 means for setting a current storage device indicator to specify a primary location
7 of the segment to be transferred next;

means for incrementing the current storage device indicator to a next location of the segment to be transferred, if the transfer of said segment causes the loading of the storage device containing said segment to be exceeded; and means for repeated executing step c) until said loading is not exceeded.

70. The apparatus of claim 68 wherein transferring of the segments of the data object comprises the actions of reading said segments from the data storage device, writing said segments to the data storage device, and copying said segments from a said data storage device to an alternate data storage device, whereby said loading of the data storage device is allocated between the reading, writing, and copying of the segments to prevent interference with said reading of the segments.

71. The apparatus of claim 68 wherein the requested data object is a video data file to be streamed isochronously to the requesting computer system.

72. A medium for retaining a computer program which, when executed on a computing system, balances a loading of storage devices attached to multiple computing systems, whereby said program executes the steps of:

acquiring a listing of locations of all segments of a requested data object including all copies of said segments and sub-segments of the requested data object; evaluating the loading of the storage devices attached to the multiple computing systems containing all copies of all segments of a requested data object;

9 selecting storage devices containing copies of each segment of the data object
10 having a least loading, which is less than a maximum loading for said
11 storage devices;

12 if the loading of the storage devices is greater than the maximum loading for
13 said storage devices, generating a sub-segment list for any segment of the
14 requested data object residing on said storage device would have a loading
15 greater than the maximum loading if said segment of the requested data
16 object were transferred, determining a load margin for all available storage
17 devices, assigning locations for each sub-segment on each available
18 storage device having the least loading, and assigning file names to each
19 sub-segment;

20 selecting said each available storage device containing each sub-segment; and

21 transferring those segments of said requested data object to a requesting
22 computer system.

1 73. The medium of claim 72 wherein calculating the new sub-segment size list
2 comprises the steps of:

3 determining a number of all available storage devices that may retain a plurality
4 of sub-segments of said sub-segment of the requested data object;

5 determining a maximum data object transfer load for the available storage
6 devices;

assigning a minimum sub-segment size which is the smallest amount of data to be contained within one sub-segment of the segment;

calculating a first sub-segment size as a first function of a number of the storage devices, the current digital data transfer load, the maximum digital data transfer load, and the minimum sub-segment size;

assigning a last sub-segment size as the minimum sub-segment size;

calculating all remaining sub-segment sizes as a second function of the number of the storage devices, the current digital data transfer load, the maximum data object transfer load, and the minimum sub-segment size; and

partitioning said segment into sub-segments whereby the first sub-segment of the segment is of the first sub-segment size, the last sub-segment of the segment is of the last sub-segment size, and all the remaining sub-segments of the segment is of the remaining sub-segment sized.

74. The medium of claim 73 wherein the first function to determine the first sub-segment size is:

$$\text{SubSeg1} = \min(\text{SubSegSize}_{\min}, V/f)$$

where

SubSeg1 is the first sub-segment size,

min is the minimum function of two variables,

V is a total size of a segment of the data object, and

f is determined by the formula:

$$f = N_d + \left(\frac{M_l}{M_l - C_l} \right)$$

where

N_d is the number of storage devices available to
retain the sub-segments of the segments
of the data object,

M_l is the maximum data object transfer load, and

C_l is the current data object transfer load.

75. The medium of claim 73 wherein the second function to determine the remaining sub-segment sizes is:

$$\text{SubSegn} = \max(\text{SubSegSize}_{\min}, V/f)$$

where

SubSegn is the a sub-segment size for one sub-segment of
the remaining sub-segments,

max is the maximum function of two variables,

V is a total size of a segment of the data object, and

f is determined by the formula:

$$f = N_d + \left(\frac{M_i}{M_i - C_i} \right)$$

where

N_d is the number of storage devices available to
retain the sub-segments of the segments
of the data object,

M_i is the maximum data object transfer load, and

C_i is the current data object transfer load.

76. The medium of claim 73 wherein calculating the new sub-segment size list further comprises the step of:

determining a file interactivity factor describing a number of jumps by the
second computing system within the data object.

77. The medium of claim 76 wherein the first function is further dependent upon the file interactivity factor.

78. The medium of claim 77 wherein the first function to determine the first sub-segment size is:

3

$$\text{SubSeg1} = \min(\text{SubSegSize}_{\min}, V/f)$$

4

where

5

SubSeg1 is the first sub-segment size,

6

min is the minimum function of two variables,

7

V is a total size of a segment of the data object, and

8

f is determined by the formula:

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$$f = N_d + \left(\frac{M_i}{M_i - C_i} \right) + I$$

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where

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N_d is the number of storage devices available to
retain the sub-segments of the segments
of the data object,

14

M_i is the maximum data object transfer load,

15

C_i is the current data object transfer load, and

16

I is the file interactivity factor.

1

79. The medium of claim 73 wherein the second function is further dependent upon the

2

file interactivity factor.

80. The medium of claim 79 wherein the second function to determine the remaining sub-segment sizes is:

$$\text{SubSegn} = \max(\text{SubSegSize}_{\min}, V/f)$$

where

SubSegn is the a sub-segment size for one sub-segment of the remaining sub-segments,

max is the maximum function of two variables,

V is a total size of a segment of the data object, and

f is determined by the formula:

$$f = N_d + \left(\frac{M_i}{M_i - C_i} \right) + 1$$

where

N_d is the number of storage devices available to retain the sub-segments of the segments of the data object,

M_i is the maximum data object transfer load,

C_i is the current data object transfer load, and

17

I is the file Inter activity factor.

1 81. The medium of claim 73 wherein calculating the new sub-segment size list further
2 comprises the step of:

3 determining a file usage factor describing a number of requests for said data
4 object for a period of time.

1 82. The medium of claim 81 wherein the first function is further dependent upon the file
2 usage factor.

3 83. The medium of claim 82 wherein the first function to determine the first sub-
4 segment size is:

$$\text{SubSeg1} = \min(\text{SubSegSize}_{\min}, V/f)$$

where

SubSeg1 is the first sub-segment size,

6 **min** is the minimum function of two variables,

7 **V** is a total size of a segment of the data object, and

8 **f** is determined by the formula:

9

$$f = N_d + \left(\frac{M_i}{M_i - C_i} \right) + H$$

where

N_d is the number of storage devices available to retain the sub-segments of the segments of the data object,

M_l is the maximum data object transfer load,

C_l is the current data object transfer load, and

H is the file usage factor.

84. The medium of claim 81 wherein the second function is further dependent upon the file usage factor.

85. The medium of claim 84 wherein the second function to determine the remaining sub-segment sizes is:

$$\text{SubSegn} = \max(\text{SubSegSize}_{\min}, V/f)$$

where

SubSegn is the a sub-segment size for one sub-segment of the remaining sub-segments,

max is the maximum function of two variables,

V is a total size of a segment of the data object, and

f is determined by the formula:

$$\mathbf{f} = \mathbf{N}_d + \left(\frac{\mathbf{M}_i}{\mathbf{M}_i} - \mathbf{C}_i \right) + \mathbf{H}$$

where

N_d is the number of storage devices available to
retain the sub-segments of the segments
of the data object,

M_i is the maximum data object transfer load,

C_i is the current data object transfer load, and

H is the file usage factor.

86. The medium of claim 73 wherein calculating the new sub-segment size list further comprises the steps of:

determining a file usage factor describing a number of requests for said data

object for a period of time; and

determining a file interactivity factor describing a number of jumps by the

second computing system within the data object.

87. The medium of claim 86 wherein the first function is further dependent upon the file usage factor and the file interactivity factor.

88. The medium of claim 87 wherein the first function to determine the first sub-segment size is:

$$\text{SubSeg1} = \min(\text{SubSegSize}_{\min}, V/f)$$

where

SubSeg1 is the first sub-segment size,

min is the minimum function of two variables,

V is a total size of a segment of the data object, and

f is determined by the formula:

$$f = N_d + \left(\frac{M_i}{M_i - C_i} \right) + H + I$$

where

N_d is the number of storage devices available to retain the sub-segments of the segments of the data object,

M_i is the maximum data object transfer load,

C_i is the current data object transfer load,

H is the file usage factor, and

I is the file Inter activity factor.

89. The medium of claim 86 wherein the second function is further dependent upon the file usage factor and the file interactivity factor.

90. The medium of claim 89 wherein the second function to determine the remaining sub-segment sizes is:

$$\text{SubSegn} = \max(\text{SubSegSize}_{\min}, V/f)$$

where

SubSegn is the a sub-segment size for one sub-segment of the remaining sub-segments,

max is the maximum function of two variables,

V is a total size of a segment of the data object, and

f is determined by the formula:

$$f = N_d + \left(\frac{M_i}{M_i - C_i} \right) + H$$

where

N_d is the number of storage devices available to retain the sub-segments of the segments of the data object,

M_i is the maximum data object transfer load,

C_i is the current data object transfer load, and

H is the file usage factor.

91. The medium of claim 73 further comprising the steps of:

determining the presence of all segments and sub-segments of the requested data object;

if there are missing segments and sub-segments of the requested data object, assigning each of those missing segments a file identification and file location, such that those missing segments are assigned to data storage devices having the least loading; and

retrieving those missing segments from a back-up storage device.

92. The medium of claim 91 wherein selecting the storage devices containing copies of the segments and sub-segments of the requested data object and having the least loading comprises the steps of:

setting a current segment indicator to indicate which of the segments of the data object is to be transferred next;

setting a current storage device indicator to specify a primary location of the segment to be transferred next;

8 if the transfer of said segment causes the loading of the storage device
9 containing said segment to be exceeded, incrementing the current storage
10 device indicator to a next location of the segment to be transferred; and
11 repeated executing step c) until said loading is not exceeded.

1 93. The medium of claim 73 wherein transferring of the segments of the data object
2 comprises the actions of reading said segments from the data storage device,
3 writing said segments to the data storage device, and copying said segments from
4 a said data storage device to an alternate data storage device, whereby said
loading of the data storage device is allocated between the reading, writing, and
copying of the segments to prevent interference with said reading of the segments.

94. The medium of claim 55 wherein the requested data object is a video data file to be
streamed isochronously to the requesting computer system.

95. A method for balancing a loading of a storage device containing video data objects
attached to multiple computing systems comprising the steps of:

3 acquiring a listing of locations of all segments of a requested video data object
4 including all copies of said segments of the requested video data object;
5 evaluating the loading of the storage devices attached to the multiple computing
6 systems containing all copies of all segments of a requested video data
7 object;

8 selecting storage devices containing copies of each segment of the video data
9 object having a least loading, which is less than a maximum loading for said
10 storage devices;

11 if the loading of the storage devices is greater than the maximum loading for
12 said storage devices, generating a sub-segment list for any segment of the
13 requested video data object residing on said storage device would have a
14 loading greater than the maximum loading if said segment of the requested
15 video data object were transferred, determining a load margin for all
16 available storage devices, assigning locations for each sub-segment on
17 each available storage device having the least loading, and assigning file
18 names to each sub-segment;

19 selecting said each available storage device containing each sub-segment; and

20 transferring those segments of said requested video data object to a requesting
21 computer system.

1 96. The method of claim 95 wherein calculating the new sub-segment size list
2 comprises the steps of:

3 determining a number of all available storage devices that may retain a plurality
4 of sub-segments of said sub-segment of the requested video data object;

5 determining a maximum video data object transfer load for the available storage
6 devices;

7 assigning a minimum sub-segment size which is the smallest amount of data to
8 be contained within one sub-segment of the segment;

9 calculating a first sub-segment size as a first function of a number of the storage
10 devices, the current digital data transfer load, the maximum digital data
11 transfer load, and the minimum sub-segment size;

12 assigning a last sub-segment size as the minimum sub-segment size;

13 calculating all remaining sub-segment sizes as a second function of the number
14 of the storage devices, the current digital data transfer load, the maximum
15 video data object transfer load, and the minimum sub-segment size; and

16 partitioning said segment into sub-segments whereby the first sub-segment of
17 the segment is of the first sub-segment size, the last sub-segment of the
18 segment is of the last sub-segment size, and all the remaining sub-
19 segments of the segment is of the remaining sub-segment sized.

1 97. The method of claim 96 wherein the first function to determine the first sub-
2 segment size is:

$$3 \quad \text{SubSeg1} = \min(\text{SubSegSize}_{\min}, V/f)$$

4 where

5 **SubSeg1** is the first sub-segment size,

6 **min** is the minimum function of two variables,

V is a total size of the video data object, and

f is determined by the formula:

$$f = N_d + \left(\frac{M_i}{M_i - C_i} \right)$$

where

N_d is the number of storage devices available to retain the sub-segments of the video data object,

M_i is the maximum video data object transfer load, and

C_i is the current video data object transfer load.

98. The method of claim 96 wherein the second function to determine the remaining sub-segment sizes is:

$$\text{SubSegn} = \max(\text{SubSegSize}_{\min}, V/f)$$

where

SubSegn is the a sub-segment size for one sub-segment of the remaining sub-segments,

max is the maximum function of two variables,

V is a total size of the video data object, and

f is determined by the formula:

$$f = N_d + \left(\frac{M_i}{M_i - C_i} \right)$$

where

N_d is the number of storage devices available to
retain the sub-segments of the video data
object,

M_i is the maximum video data object transfer
load, and

C_i is the current video data object transfer load.

99. The method of claim 96 wherein calculating the new sub-segment size list further
comprises the step of:

determining a file interactivity factor describing a number of jumps by the
second computing system within the video data object.

100. The method of claim 99 wherein the first function is further dependent upon the file
interactivity factor.

101. The method of claim 100 wherein the first function to determine the first sub-
segment size is:

$$\text{SubSeg1} = \min(\text{SubSegSize}_{\min}, V/f)$$

where

SubSeg1 is the first sub-segment size,

min is the minimum function of two variables,

V is a total size of the video data object, and

f is determined by the formula:

$$f = N_d + \left(\frac{M_i}{M_i - C_i} \right) + I$$

where

N_d is the number of storage devices available to
retain the sub-segments of the video data
object,

M_i is the maximum video data object transfer
load,

C_i is the current video data object transfer load,
and

I is the file interactivity factor.

1 102. The method of claim 99 wherein the second function is further dependent upon the
2 file interactivity factor.

1 103. The method of claim 102 wherein the second function to determine the remaining
2 sub-segment sizes is:

3
$$\text{SubSegn} = \max(\text{SubSegSize}_{\min}, V/f)$$

4 where

5 **SubSegn** is the a sub-segment size for one sub-segment of
6 the remaining sub-segments,

7 **max** is the maximum function of two variables,

8 **V** is a total size of the video data object, and

9 **f** is determined by the formula:

10
$$f = N_d + \left(\frac{M_i}{M_i - C_i} \right) + 1$$

11 where

12 **N_d** is the number of storage devices available to
13 retain the sub-segments of the video data
14 object,

M_i is the maximum video data object transfer

load,

C_i is the current video data object transfer load,

and

I is the file Inter activity factor.

104. The method of claim 96 wherein calculating the new sub-segment size list further comprises the step of:

determining a file usage factor describing a number of requests for said video data object for a period of time.

105. The method of claim 104 wherein the first function is further dependent upon the file usage factor.

106. The method of claim 105 wherein the first function to determine the first sub-segment size is:

$$\text{SubSeg1} = \min(\text{SubSegSize}_{\min}, V/f)$$

where

SubSeg1 is the first sub-segment size,

min is the minimum function of two variables,

V is a total size of the video data object, and

f is determined by the formula:

$$f = N_d + \left(\frac{M_l}{M_l - C_l} \right) + H$$

where

N_d is the number of storage devices available to
retain the sub-segments of the video data
object,

M_l is the maximum video data object transfer
load,

C_l is the current video data object transfer load,
and

H is the file usage factor.

107. The method of claim 104 wherein the second function is further dependent upon
the file usage factor.

108. The method of claim 107 wherein the second function to determine the remaining
sub-segment sizes is:

$$\text{SubSegn} = \max(\text{SubSegSize}_{\min}, V/f)$$

where

SubSegn is the a sub-segment size for one sub-segment of
the remaining sub-segments,

max is the maximum function of two variables,

V is a total size of the video data object, and

f is determined by the formula:

$$f = N_d + \left(\frac{M_l}{M_l - C_l} \right) + H$$

where

N_d is the number of storage devices available to
retain the sub-segments of the video data
object,

M_l is the maximum video data object transfer
load,

C_l is the current video data object transfer load,
and

H is the file usage factor.

109. The method of claim 96 wherein calculating the new sub-segment size list further
comprises the steps of:

determining a file usage factor describing a number of requests for said video data object for a period of time; and

determining a file interactivity factor describing a number of jumps by the second computing system within the video data object.

110. The method of claim 109 wherein the first function is further dependent upon the file usage factor and the file interactivity factor.

111. The method of claim 110 wherein the first function to determine the first sub-segment size is:

$$\text{SubSeg1} = \min(\text{SubSegSize}_{\min}, V/f)$$

where

SubSeg1 is the first sub-segment size,

min is the minimum function of two variables,

V is a total size of the video data object, and

f is determined by the formula:

$$f = N_d + \left(\frac{M_i}{M_i - C_i} \right) + H + I$$

where

N_d is the number of storage devices available to
retain the sub-segments of the video data
object,

M_l is the maximum video data object transfer
load,

C_l is the current video data object transfer load,

H is the file usage factor, and

I is the file Inter activity factor.

112. The method of claim 109 wherein the second function is further dependent upon
the file usage factor and the file interactivity factor.

113. The method of claim 113 wherein the second function to determine the remaining
sub-segment sizes is:

$$\text{SubSegn} = \max(\text{SubSegSize}_{\min}, V/f)$$

where

SubSegn is the a sub-segment size for one sub-segment of
the remaining sub-segments,

max is the maximum function of two variables,

V is a total size of the video data object, and

f is determined by the formula:

$$f = N_d + \left(\frac{M_l}{M_l - C_l} \right) + H$$

where

N_d is the number of storage devices available to retain the sub-segments of the video data object,

M_l is the maximum video data object transfer load,

C_l is the current video data object transfer load, and

H is the file usage factor.

114. The method of claim 96 further comprising the steps of:

determining the presence of all segments of the requested video data object;

if there are missing segments of the requested video data object, assigning each of those missing segments a file identification and file location, such that those missing segments are assigned to data storage devices having the least loading; and

retrieving those missing segments from a back-up storage device.

1 115. The method of claim 96 wherein selecting the storage devices containing copies of
2 the segments of the requested video data object and having the least loading
3 comprises the steps of:

4 setting a current segment indicator to indicate which of the segments of the
5 video data object is to be transferred next;

6 setting a current storage device indicator to specify a primary location of the
7 segment to be transferred next;

8 if the transfer of said segment causes the loading of the storage device
9 containing said segment to be exceeded, incrementing the current storage
10 device indicator to a next location of the segment to be transferred; and
11 repeated executing step c) until said loading is not exceeded.

12 116. The method of claim 96 wherein transferring of the segments of the video data
13 object comprises the actions of reading said segments from the data storage
14 device, writing said segments to the data storage device, and copying said
15 segments from a said data storage device to an alternate data storage device,
16 whereby said loading of the data storage device is allocated between the reading,
17 writing, and copying of the segments to prevent interference with said reading of
18 the segments.

1 117. The method of claim 96 wherein the requested video data object is streamed
2 isochronously to the requesting computer system.

1 118. A video data object service system in communication with a plurality of computing
2 systems to provide at least one video data object of plurality of video data object to
3 at least one of the plurality of computing system, comprising:

4 a plurality of video data object storage devices in communication with each
5 other and with any of the plurality of computing systems; and

6 a load balancing apparatus in communication with the plurality of video data
7 object storage devices to balance a loading of said video data object storage
8 devices during transfer of said video data objects,

9 whereby said load balancing apparatus comprises:

10 a load evaluator to assess the loading of the video data object storage
11 devices containing segments of said video data objects,

12 a storage device selector to create a selection list to indicate selection of
13 those video data object storage devices containing copies of each
14 segment of the requested video data object having the least loading,
15 and

16 a coping initiator to initiate a copying of a segment of the video data
17 object to an alternate storage device having low loading if all storage
18 devices containing said segment have a loading greater than a
19 maximum loading.

20 a coping initiator to initiate a copying and further segmenting of a
21 segment of the video data object to an alternate storage devices
22 having low loading if all storage devices containing said segment
23 have a loading greater than a maximum loading, whereby said
24 copying initiator generates a sub-segment list for any segment of the
25 requested video data object residing on said storage device that
26 would have a loading greater than the maximum loading if said
27 segment of the requested video data object were transferred,
28 determines a load margin for all available storage devices, assigns
29 locations for each sub-segment on each available storage device
30 having the least loading, and assigns file names to each sub-
31 segment;

119. The system of claim 118 wherein calculating the new sub-segment size list
comprises the steps of:

determining a number of all available storage devices that may retain a plurality
of sub-segments of said sub-segment of the requested video data object;

determining a maximum video data object transfer load for the available storage
devices;

assigning a minimum sub-segment size which is the smallest amount of data to
be contained within one sub-segment of the segment;

calculating a first sub-segment size as a first function of a number of the storage devices, the current digital data transfer load, the maximum digital data transfer load, and the minimum sub-segment size;

assigning a last sub-segment size as the minimum sub-segment size;

calculating all remaining sub-segment sizes as a second function of the number of the storage devices, the current digital data transfer load, the maximum video data object transfer load, and the minimum sub-segment size; and

partitioning said segment into sub-segments whereby the first sub-segment of the segment is of the first sub-segment size, the last sub-segment of the segment is of the last sub-segment size, and all the remaining sub-segments of the segment is of the remaining sub-segment sized.

120. The system of claim 119 wherein the first function to determine the first sub-segment size is:

$$\text{SubSeg1} = \min(\text{SubSegSize}_{\min}, V/f)$$

where

SubSeg1 is the first sub-segment size,

min is the minimum function of two variables,

V is a total size of the video data object, and

f is determined by the formula:

$$f = N_d + \left(\frac{M_l}{M_l - C_l} \right)$$

where

N_d is the number of storage devices available to retain the sub-segments of the video data object,

M_l is the maximum video data object transfer load, and

C_l is the current video data object transfer load.

121. The system of claim 119 wherein the second function to determine the remaining sub-segment sizes is:

$$\text{SubSegn} = \max(\text{SubSegSize}_{\min}, V/f)$$

where

SubSegn is the a sub-segment size for one sub-segment of the remaining sub-segments,

max is the maximum function of two variables,

V is a total size of the video data object, and

f is determined by the formula:

$$f = N_d + \left(\frac{M_i}{M_i - C_i} \right)$$

where

- (a) **N_d** is the number of storage devices available to retain the sub-segments of the video data object,
- (b) **M_i** is the maximum video data object transfer load, and
- (c) **C_i** is the current video data object transfer load.

122. The system of claim 119 wherein calculating the new sub-segment size list further comprises the step of:

determining a file interactivity factor describing a number of jumps by the second computing system within the video data object.

123. The system of claim 122 wherein the first function is further dependent upon the file interactivity factor.

124. The system of claim 123 wherein the first function to determine the first sub-segment size is:

$$\text{SubSeg1} = \min(\text{SubSegSize}_{\min}, V/f)$$

where

SubSeg1 is the first sub-segment size,

min is the minimum function of two variables,

V is a total size of the video data object, and

f is determined by the formula:

$$f = N_d + \left(\frac{M_l}{M_l - C_l} \right) + I$$

where

- (a) **N_d** is the number of storage devices available to retain the sub-segments of the video data object,
- (b) **M_l** is the maximum video data object transfer load,
- (c) **C_l** is the current video data object transfer load, and
- (d) **I** is the file interactivity factor.

125. The system of claim 122 wherein the second function is further dependent upon the file interactivity factor.

126. The system of claim 125 wherein the second function to determine the remaining sub-segment sizes is:

$$\text{SubSegn} = \max(\text{SubSegSize}_{\min}, V/f)$$

where

SubSegn is the a sub-segment size for one sub-segment of the remaining sub-segments,

max is the maximum function of two variables,

V is a total size of the video data object, and

f is determined by the formula:

$$f = N_d + \left(\frac{M_i}{M_i - C_i} \right) + I$$

where

(a) **N_d** is the number of storage devices available to retain the sub-segments of the video data object,

(b) M_I is the maximum video data
object transfer load,

(c) C_I is the current video data object
transfer load, and

(d) I is the file Inter activity factor.

127. The system of claim 119 wherein calculating the new sub-segment size list further
comprises the step of:

determining a file usage factor describing a number of requests for said video
data object for a period of time.

128. The system of claim 127 wherein the first function is further dependent upon the file
usage factor.

129. The system of claim 128 wherein the first function to determine the first sub-
segment size is:

$$\text{SubSeg1} = \min(\text{SubSegSize}_{\min}, V/f)$$

where

SubSeg1 is the first sub-segment size,

min is the minimum function of two variables,

V is a total size of the video data object, and

f is determined by the formula:

$$f = N_d + \left(\frac{M_i}{M_i - C_i} \right) + H$$

where

- (a) **N_d** is the number of storage devices available to retain the sub-segments of the video data object,
- (b) **M_i** is the maximum video data object transfer load,
- (c) **C_i** is the current video data object transfer load, and
- (d) **H** is the file usage factor.

130. The system of claim 127 wherein the second function is further dependent upon the file usage factor.

131. The system of claim 130 wherein the second function to determine the remaining sub-segment sizes is:

$$\text{SubSegn} = \max(\text{SubSegSize}_{\min}, V/f)$$

where

SubSegn is the a sub-segment size for one sub-segment of the remaining sub-segments,

max is the maximum function of two variables,

V is a total size of the video data object, and

f is determined by the formula:

$$f = N_d + \left(\frac{M_i}{M_i - C_i} \right) + H$$

where

- (a) **N_d** is the number of storage devices available to retain the sub-segments of the video data object,
- (b) **M_i** is the maximum video data object transfer load,
- (c) **C_i** is the current video data object transfer load, and
- (d) **H** is the file usage factor.

132. The system of claim 119 wherein calculating the new sub-segment size list further comprises the steps of:

determining a file usage factor describing a number of requests for said video data object for a period of time; and

determining a file interactivity factor describing a number of jumps by the second computing system within the video data object.

133. The system of claim 132 wherein the first function is further dependent upon the file usage factor and the file interactivity factor.

134. The system of claim 133 wherein the first function to determine the first sub-segment size is:

$$\text{SubSeg1} = \min(\text{SubSegSize}_{\min}, V/f)$$

where

SubSeg1 is the first sub-segment size,

min is the minimum function of two variables,

V is a total size of the video data object, and

f is determined by the formula:

$$f = N_d + \left(\frac{M_i}{M_i - C_i} \right) + H + I$$

where

N_d is the number of storage devices available to retain the sub-segments of the video data object,

M_l is the maximum video data object transfer load,

C_l is the current video data object transfer load,

H is the file usage factor, and

I is the file Inter activity factor.

135. The system of claim 132 wherein the second function is further dependent upon the file usage factor and the file interactivity factor.

136. The system of claim 135 wherein the second function to determine the remaining sub-segment sizes is:

$$\text{SubSegn} = \max(\text{SubSegSize}_{\min}, V/f)$$

where

SubSegn is the a sub-segment size for one sub-segment of the remaining sub-segments,

max is the maximum function of two variables,

V is a total size of the video data object, and

f is determined by the formula:

$$f = N_d + \left(\frac{M_i}{M_i - C_i} \right) + H$$

where

- (a) **N_d** is the number of storage devices available to retain the sub-segments of the video data object,
- (b) **M_i** is the maximum video data object transfer load,
- (c) **C_i** is the current video data object transfer load, and
- (d) **H** is the file usage factor.

137. The system of claim 100 wherein the load balancing apparatus generates a listing of all copies of all segments of the requested video data objects.

138. The system of claim 100 wherein a data storage device having a copied segment of the requested video data object is selected to transfer said video data object to a requesting computing system.

139. The system of claim 100 wherein the load balancing apparatus comprises:

2 a presence determining device to determine the presence of all segments of the
3 requested video data object; and

4 a segment retrieving device which, if there are missing segments of the
5 requested video data object, said segment retrieving device assigns each of
6 those missing segments a file identification and file location, such that those
7 missing segments are assigned to data storage devices having the least
8 loading, and then said segment retrieving device retrieves those missing
9 segments from a back-up storage device.

10 140. The system of claim 118 wherein the load balancing apparatus further comprises:

11 a segment indicator that is set to indicate which of the segments of the video
12 data object to be transferred next; and

13 a current storage device indicator to specify initially a primary location of the
14 segment identified by the segment indicator;

15 whereby the load balancing apparatus

16 determines if the loading of the data storage device indicated by the
17 current storage device indicator exceeds the maximum loading with
18 transfer of the segment indicated by the segment indicator,

19 if said loading exceeds the maximum loading, the current storage device
20 indicator is set to a next location of the segment indicated by the
21 segment indicator, and
22

13 repeated executes steps a) and b) until said loading is not exceeded.

1 141. The system of claim 118 wherein transferring of the segments of the video data
2 object comprises the actions of reading said segments from the data storage
3 device, writing said segments to the data storage device, and copying said
4 segments from a said data storage device to an alternate data storage device,
5 whereby said loading of the data storage device is allocated between the reading,
6 writing, and copying of the segments to prevent interference with said reading of
7 the segments.

142. The system of claim 118 wherein the requested video data object is streamed
isochronously to the requesting computer system.